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QUARTERLY PROGRESS REPORT NUMBER 1, 1 AUGUST - 31 OCTOBER 1966.(U)
DEC 66 NOBSR-95181

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QUARTERLY PROGRESS REPORT NO. 1 Number 1

under

CONTRACT NObsr-95181

Project Serial No. SF 1010316

Task 8641

1 August - 31 October 1966.

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12 December 1966

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CONTRACT NObsr-95181
FIRST QUARTERLY PROGRESS REPORT
for the period
1 August - 31 October 1966

I. INTRODUCTION

The starting date for Contract NObsr-95181 was officially set as 25 April 1966, however the contract was not received and signed until 25 July 1966. As a result of this delay, work was not started officially until approximately 1 August 1966. This, the first quarterly report includes the period of 1 August through 31 October 1966.

Contract NObsr-95181 has two basic parts--one to investigate the utility of cepstrum alanysis as an aid to active sonar classification, and the other to develop computer techniques to help with the problem of choosing sonar systems and specific relevant proposals on the basis of optimum (cost-effectiveness) return.

A. Cepstrum Alanysis

On this project several studies are being pursued which we hope will contribute to our future progress on this problem.

Some work generally in the area of Shannon's theorem has yielded rather remarkable results. We find that data sampled at the Shannon rate (as determined by an external analog filter) are not adequate to reproduce the original waveform, whereas data that have been digitally filtered are not only accurately reproduced but can be so reproduced very rapidly.

As mentioned in the preceding paragraph, digital filtering techniques may be quite important to some of these studies; i.e., a digital filter is recommended as one step in the cepstrum alanysis. As another example, this technique will give us an entirely separate approach to the investigation of spectral properties of waveforms. A more detailed discussion of the digital filtering work follows.

Some computer subroutines that will speed up the standard time series analysis operations of correlation and Fourier transform are being written to allow for the processing of larger quantities of data in the available time.

B. PERT

This first quarter of the PERT study was devoted to a literature search and study program designed to fix on a specific approach that might be suitable for further application. Although several different techniques worked on various problems, the fastest and most universally applicable technique was the simple sorting routine. Progress on this problem has been slow because of manpower problems, but a further discussion of this early work also follows.

1. Digital Filters

The use of digital filters may be quite advantageous in the processing of sampled time series. In many cases, the desired signal-to-noise ratio is reached only through the proper use of one or more filters on the existing physical data. A few of the advantages of numerical or digital filters over analog filters are:

(1) Digital filters possess higher fidelity; i.e., they can be reproduced to a high degree of accuracy.

(2) Digital filters are not hardware bound and can be readily designed.

(3) Digital filters have response characteristics that can be instantaneously changed.

(4) Digital filters can be used more directly for digital computer applications.

The category digital filters includes both polynomial smoothing and numerical filtering. Polynomial smoothing, however, is not a sharp cutoff filter process, whereas numerical filtering is usually thought of as sharp cutoff filtering.

In the derivation of linear filter theory, the processes are considered to be continuous in the time domain. However, any practical numerical computations must be limited in time. This restriction presents a band-limited frequency response function in the frequency domain, or a truncated weight function in the time domain. This truncation can be accomplished by two general methods.

(1) One can modify the ideal frequency response in the frequency domain by allowing a rolloff of finite slope and truncating the resulting weight function in the time domain.

(2) One can truncate the ideal weight function in the time domain by some appropriate technique.

Both of these methods have been investigated with the CDC 3200 computer. It is felt that method (1) produces a filter with greater rejection, steeper slopes, and a more controllable bandwidth characteristic.

Routines for designing lowpass, highpass, and bandpass filters for use with the analysis of sampled time series have been implemented for the CDC 3200 computer. These routines will be incorporated with other computer routines being developed to simulate various types of existing analog spectrum analyzers. These analyzers will be used to analyze the existing short pulse data available.

2. Basic Models for PERT Program

It is the objective of this research program to develop a technique for simulating active and passive sonar systems with the aid of a digital electronic computer, and to evaluate various system combinations with respect to certain prescribed operational requirements. Mathematical modeling of the systems will facilitate a relative scaling of their performance for overall effectiveness. With this capability, supervising agents overseeing a large number of independent research programs should be better able to coordinate them - in fact, realistic modeling of sonar systems may very well eliminate

many system combinations incompatible for one reason or another. It should be emphasized that the computer model will serve only as an aid in decision-making: the final responsibility for funding rests with the contracting officers themselves.

In a long range development program, with many contracts entering and leaving the system over several years, the use of PERT or CPM supervision will be necessary to make efficient use of the time.

To build a strong computer capability, CPM, PERT-TIME, and PERT-COST routines were applied to representative problems to prove their utility. An extensive mathematical Programming Package was acquired for use in optimization of the various measures of effectiveness to be chosen for the sonar systems.

Several methods were investigated to determine the optimum system configuration from many possible equipment combinations. In the absence of an accurate picture of a working sonar system, hypothetical models were constructed in the form of black boxes representing system components and were connected in straight chains, loops, and branches. Measures of effectiveness were determined from relations at the interfaces and such surface considerations as maximum weight, maximum cost, minimum signal-to-noise ratio, etc. After coding this properly into the computer, several optimization techniques, including the methods of Lagrange multiplier and nonlinear programming, were applied to find the best design for the system. By representing the system as a sequence of black boxes, Dynamic Programming was found to be of some usefulness, although not applicable in every case. In every case, however, a simple sorting routine was quite adequate to evaluate the various system proposals.

A program is now being prepared to represent a hypothetical system on the computer and to examine alternate courses from among N system proposals and to chose the most likely X-percent according to some desired operating characteristics. It should be possible with the help of the A/D and D/A equipment to change the value of a single parameter(s) in a subcomponent and obtain an immediate display of its effect on the overall performance.

It is hoped that the output from this computer program will lead to a realistic choice of black boxes and corresponding interfaces since the next logical step in the procedure is to include these choices into the computer program and to evaluate the effectiveness of the program itself.

12 December 1966

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